Coarsening Dynamics and Marangoni Effects in Thin Liquid Crystal Bubbles in Microgravity

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Agenda

- ◆ **Introduction & Science Background**
  - – **Science background**
  - – **Motivation for microgravity research**

- ◆ **Proposed Space Experiment**
  - – **Objectives**
  - – **Science requirements, Engineering Approach & Development**

- ◆ **Video of preliminary results of OASIS flight experiments**

Ultra-Thin Freely Suspended Liquid Crystal Films

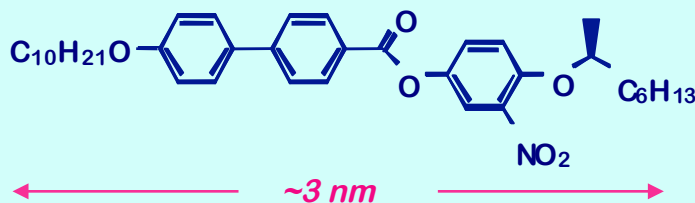- ◆ **Quantized thickness** *(3 nm for a single molecular layer)*

  Thinnest known stable condensed phase structures and have the largest surface-to-volume ratio of any condensed phase preparation, making them ideal for studies of fluctuation and interface phenomena

- ◆ **Stable fluid structures**

  reflection microscope image

- ◆ **Largest surface-to-volume ratio**

  SmA
  (no in-plane structure)

- ◆ **Low vapor pressure**

  ~ 60 layers

  ~ 50 layers

  ~ 40 layers

  ~ 25 layers

  ~ 10 layers

  ~ 2 layers

W314 - typical film-forming molecule

$C_{10}H_{21}O$ —⟨ ⟩—⟨ ⟩— $\overset{O}{\underset{O}{C}}$ —⟨ ⟩— O — C_6H_{13}

NO_2

~3 nm

$R \propto N^2$

R (mV)   Reflectivity
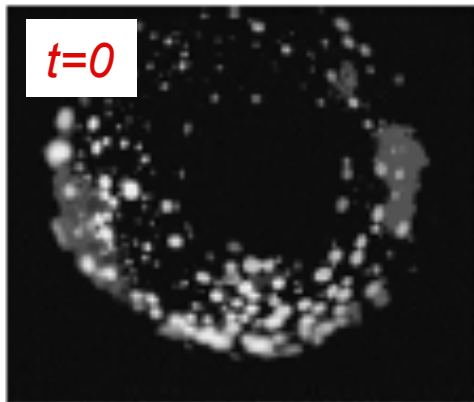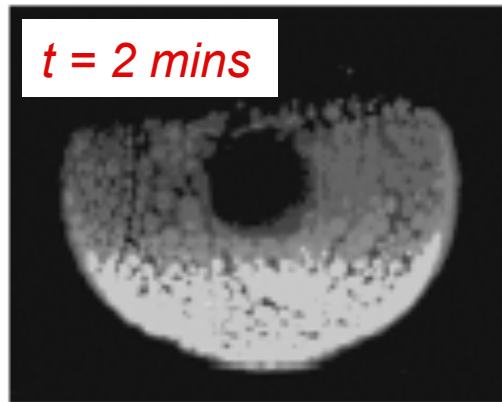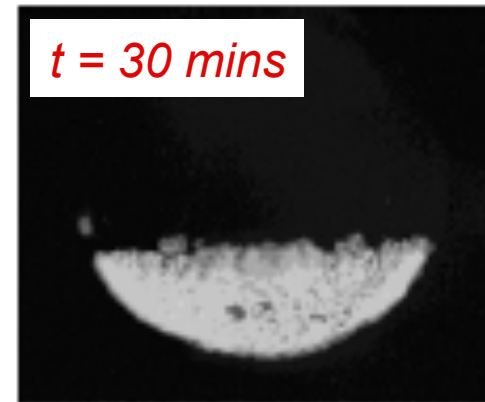
$R \propto \sin^2(N)$
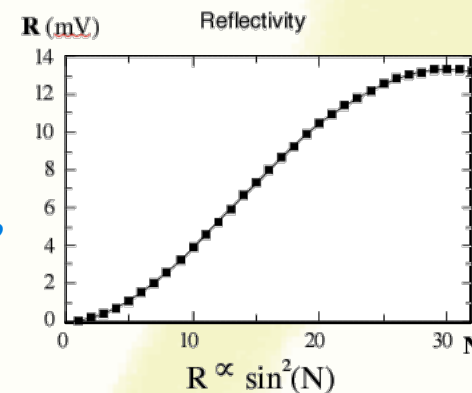
Justification for Microgravity

t=0   t = 2 mins   t = 30 mins
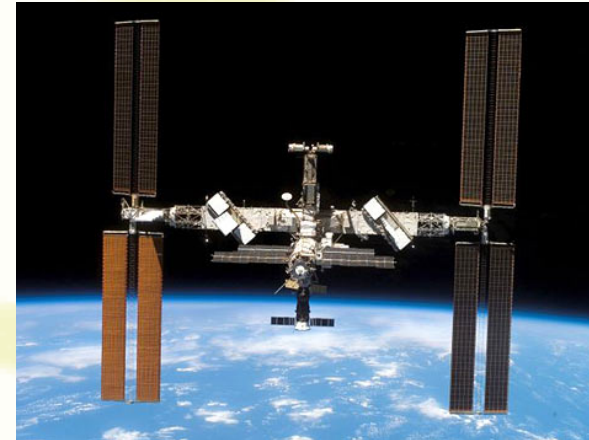
LC Material: 8CB

Perrin Length = $K_bT/m*g$

For a colloidal suspension with 10 microns, the PL is on the order of meters

Smectic Islands of 10 microns diameter, mass of 10^{-15} Kg , PL is much larger than the bubble diameter
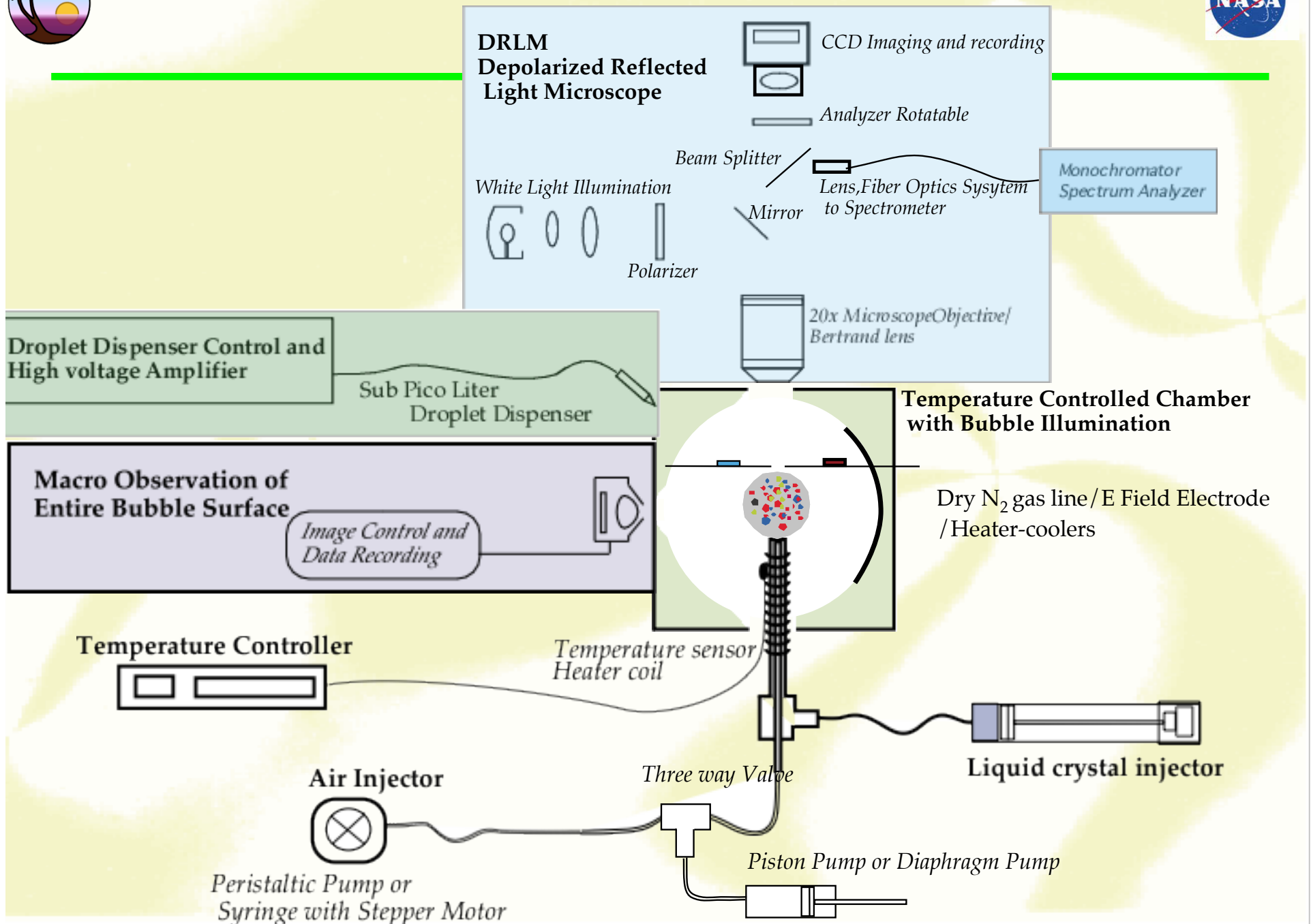
Science Objectives in Microgravity

- **2D Hydrodynamics**
  - *Hydrodynamics of islands and droplets*

- **1D Interfaces in 2D Space**
  - *Coarsening & Ostwald ripening*
  - *Island interactions*

- **Thermocapillary Effects**
  - *Marangoni effect*

- **Surface and Line Tension**
  - *Dependence on film thickness*

- **Textural Interactions**
  - *Interactions of islands/droplets and defects*

- **Ultraweak Interactions**
  - *Interactions of islands*
  - *Effects of perturbing bubbles*

OASIS Instrumentation

DRLM
Depolarized Reflected
Light Microscope

CCD Imaging and recording

Analyzer Rotatable

Beam Splitter

White Light Illumination

Lens,Fiber Optics Sysytem
to Spectrometer

Mirror

Monochromator
Spectrum Analyzer

Polarizer

20x MicroscopeObjective/
Bertrand lens

Droplet Dispenser Control and
High voltage Amplifier

Sub Pico Liter
Droplet Dispenser

Temperature Controlled Chamber
with Bubble Illumination

Macro Observation of
Entire Bubble Surface

Image Control and
Data Recording

Dry N_2 gas line/E Field Electrode
/Heater-coolers

Temperature Controller

Temperature sensor
Heater coil

Liquid crystal injector

Three way Valve

Air Injector

Piston Pump or Diaphragm Pump

Peristaltic Pump or
Syringe with Stepper Motor

OASIS

- **Creating a very thin bubble and making pancake like structures – islands (island emulsions on the bubble)**
- **Study of long term coarsening of island structures**
- **Observation of Plateau-Ryaleigh Instability**
- **Thermomigration and thermocapillary effects of islands**
- **Plateau – Rayleigh Instability**
- **Coarsening of pores**
- **Study of phase transition changes**
- **Island interactions with external electric field**

- ◆ *Coarsening*

◆ **Thermo-migration**

Real time video observation of OASIS

◆ **Phase transition changes**

Real time video observation of OASIS

- ◆ *Droplet studies*

◆ **External electric field effects**

Real time video observation of OASIS

◆ **Plateau-Rayleigh Instability**

Current status of OASIS and on orbit operations

- **OASIS software engineer created data and command displays to support ground operations (Ops) at the TSC.**
- **The OASIS Ops team is receiving, displaying and storing downlink data to be reviewed by researchers.**
- **Science team members observe near real time video and control physical parameters.**
- **During Ops, science team members work with the ZIN Ops team to uplink commanding functions (camera zoom, gain control,adjustment, change of physical parameters, creating bubbles, shearing, etc.).**
- **The OASIS Avionics box swaps out 1 TB hard-drives which are used to store physical parameters and high resolution macro and micro video data.**
- **OASIS science experiment will continue it operations until December garnering scientific results.**

Acknowledgement

Thank you